FINGER FOLLOWER

FIELD OF THE INVENTION

The present invention relates to engines and, more particularly, to finger followers useable in engines.

BACKGROUND

Engines of all kinds utilize gasoline or other petroleum based products as a source of fuel. Particularly, internal combustion engines utilize such fuel. These types of engines typically include a fuel inlet chamber, an exhaust chamber, a camshaft, and a valve operating assembly for each chamber for regulating the opening and closing of the chambers.

These valve operating assemblies include a finger follower engageable by a cam on the camshaft. The finger follower typically includes a main body, a rotatable cam member or cam follower that rotates with respect to the main body and engages the cam, and a solid pin positioned generally in the middle of the main body and on which the cam follower is supported and rotatable about. The solid pin is positioned in the cam follower and has a diameter similar to the inner diameter of the cam follower. Apertures are defined in the middle of the main body for supporting the solid pin and have a diameter similar to both the inner diameter of the cam follower and the diameter of the solid pin.

Such finger followers have cam follower inner diameters that are relatively large with respect to the main body and, therefore, the apertures defined in the main body must also be relatively large to accommodate the large diameter of the solid pin. Large apertures in the main body negatively effect the strength and stiffness of the finger follower and can result in damage or even failure of the finger follower under forces applied by the cam. Increased reinforcement is typically required to decrease the chance of finger follower failure. Such reinforcement creates a bulky, heavy, inefficient, and expensive finger follower that is difficult to fit into an already cramped engine. Such reinforcement also reduces finger follower design flexibility.

SUMMARY OF THE INVENTION

At least one embodiment of the present invention provides a finger follower for use in an engine. The finger follower includes a main body that defines a body aperture

therethrough and includes a first wall and a second wall spaced apart from one another on opposite sides of the body aperture. The first wall defines a first aperture therein and the second wall defines a second aperture therein, the first and second apertures each having a diameter. The finger follower also includes a shaft assembly that has a first portion positionable between the walls and has a second diameter that is larger than the first and second aperture diameters. The shaft assembly includes secondary portions that extend from the first portion and are configured to be received in the first and second apertures. The finger follower further includes a cam follower positioned in the body aperture and rotatable about the shaft assembly first portion.

At least one embodiment of the present invention provides a finger follower including a main body that has a first wall and a second wall spaced apart from one another. The first wall has a first aperture defined therethrough and the second wall has a second aperture defined therethrough, the first and second apertures each having an aperture diameter. The finger follower also includes a shaft assembly that has a first portion and secondary portions that extend from the first portion. The first portion is positionable between the first wall and the second wall and has a first diameter greater than the aperture diameters. The secondary portions are configured to be received in the first and second apertures of the first and second walls to support the shaft assembly. The finger follower further includes a cam follower having an aperture with an inner diameter. The first portion is positionable in the cam follower aperture to support the cam follower.

At least one embodiment of the present invention provides a method of assembling a finger follower. The method includes providing a main body including a first wall having a first aperture defined therein and a second wall having a second aperture defined therein. The first and second walls are spaced apart from one another. The method also includes the steps of: providing a cam follower rotatable with respect to the main body and having a cam follower aperture therethrough; providing a hollow shaft defining a shaft aperture therethrough; inserting the hollow shaft into the cam follower aperture; positioning the cam follower and the hollow shaft between the first and second walls; aligning the shaft aperture with the first and second apertures; and inserting a second shaft into the aligned first aperture, the shaft aperture, and the second aperture such that the second shaft is supported by the first and second walls.

In addition, at least one embodiment of the present invention provides a method of assembling a finger follower. The method includes providing a main body that includes a

first wall that has a first aperture defined therein and a second wall that has a second aperture defined therein. The first and second walls are spaced apart from one another and the first and second apertures each have a diameter. The method also includes the steps of: providing a cam follower rotatable with respect to the main body and having a cam follower aperture therethrough; providing a shaft assembly that includes a first portion that has a second diameter larger than the aperture diameters and secondary portions that extend from the first portion; inserting the first portion into the cam follower aperture; and supporting the secondary portions in the first and second apertures.

Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims, and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described with reference to the accompanying drawings, which illustrate embodiments of the present invention. However, it should be noted that the invention as disclosed in the accompanying drawings is illustrated by way of example only. The various elements and combinations of elements described below and illustrated in the drawings can be arranged and organized differently to result in embodiments which are still within the spirit and scope of the present invention.

In the drawings, wherein like reference numerals indicate like parts:

Fig. 1 is a front view, in partial section, of an engine including finger followers that are a first embodiment of the present invention.

Fig. 2 is a top isometric view of a finger follower of Fig. 1.

Fig. 3 is a bottom isometric view of a finger follower of Fig. 1.

Fig. 4 is an exploded top isometric view of a finger follower of Fig. 1.

Fig. 5 is a top plan view, in partial section, of a finger follower of Fig. 1.

Fig. 6 is a sectional view along line 6-6 in Fig. 5.

Fig. 7 is a top plan view, in partial section, of a finger follower that is another embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to Fig. 1, an engine 20 is illustrated and includes two valve operating assemblies 22. The engine illustrated in Fig. 1 is for exemplary purposes only and the

present invention can be utilized with any engine and still be within the spirit and scope of the present invention. Operation of an engine is well known to those of ordinary skill in the art and, therefore, only engine operations applicable to the present invention will be discussed herein.

The valve operating assemblies 22 are substantially similar and, therefore, only one will be discussed further herein. The valve operating assembly 22 includes a rotatable overhead camshaft 24, a finger follower 28, a valve 32, and a lash adjuster 36. The valve operating assembly 22 is operable to open and close either a fuel intake chamber 40 or an exhaust chamber 44. The camshaft 24 is rotatable and includes a cam 48 engageable with the finger follower 28 to bias the valve 32 in a manner known to those of ordinary skill in the art. A tip 50 of the valve 32 is engageable with the finger follower 28 at a first end 52 of the finger follower 28 and the lash adjuster 36 is engageable with a second end 60 of the finger follower 28. The lash adjuster 36 operates in a manner known to those of ordinary skill in the art.

Referring to Figs. 2-6, the finger follower 28 includes a main body 64, a rotatable cam follower 68 interconnected to and rotatable with respect to the main body 64, a cylindrical race or hollow shaft 72, and a solid shaft 76 interconnected with the main body 64 and the hollow shaft 72.

The main body 64 includes a top surface 80, a bottom surface 84, and a body aperture 88 defined through the main body 64 from the top surface 80 to the bottom surface 84. Spaced apart side walls 92 of the main body 64 are oriented on opposite sides of the body aperture 88 and define a wall aperture 96 therein. In the illustrated embodiment, the wall apertures 96 are substantially co-axial with each other and have wall aperture diameters that are generally similar to each other, however, the wall apertures 96 do not have to be co-axial with each other and can have varying diameters from one another and still be within the spirit and scope of the present invention. Valve pallet walls 100 extend downward from the bottom surface 84 of the main body 64 and are spaced apart from one another to facilitate engagement of the tip 50 of the valve 32 therebetween. The valve pallet walls 100 limit lateral movement of the tip 50 to prevent the tip 50 from disengaging the finger follower 28 when the valve 32 undergoes lateral forces. The main body 64 also defines a lash adjuster cavity 104 in the bottom surface 84 near the second end 60 thereof for receiving an end of the lash adjuster 36.

The cam follower 68 includes a hollow cylindrical outer ring 108 that protrudes above the side walls 92 of the main body 64 and is engaged by the cam 48 of the camshaft 24. Rotation of the cam 48 causes the outer ring 108 to rotate with respect to the main body 64. To facilitate such rotation, the preferred embodiment of the cam follower 68 includes a plurality of rolling elements 112 positioned within the outer ring 108. However, other rotation facilitating means, for example, but not limited to, application of an anti-friction coating to the outer ring 108 interior surface or insertion of a non-metallic anti-friction ring within the outer ring 108, may be utilized. The outer ring 108 includes an outer ring aperture 116 defined therethrough. In the illustrated preferred embodiment, the rolling elements 112 are positioned in the outer ring aperture 116 and bear against the interior surface of the outer ring 108. When the rolling elements 112 are positioned in the outer ring aperture 116, a cam follower aperture 120 is defined by the rolling elements 112 through the center of the cam follower 68. In an embodiment that uses, for example, an anti-friction coating instead of rolling elements, the outer ring aperture 116 itself may define the cam follower aperture 120. The cam follower aperture 120 defines an inner diameter of the cam follower 68.

The hollow shaft 72 is positionable in the cam follower aperture 120 and engages the rolling elements 112 on an outer surface thereof. The hollow shaft 72 has an outer diameter substantially complementary to the inner diameter of the cam follower 68 and an inner diameter defined by a shaft aperture 124. As used herein, the term "substantially complementary" refers to the relationship between diameters of at least two elements of the finger follower and means the at least two diameters are of a size that facilitates engagement between the elements to an extent that either prevents rotation between the elements or facilitates rotation between the elements. In the illustrated embodiment, the hollow shaft 72 has a length substantially similar to the width of the cam follower 68 such that the hollow shaft 72 does not protrude beyond outer edges of the cam follower 68 when the hollow shaft 72 is positioned in the cam follower aperture 120. The hollow shaft 72 can alternatively have a length smaller than the width of the cam follower 68 or larger than the width of the cam follower 68 and still be within the spirit and scope of the present invention.

The solid shaft 76 is positionable in the shaft aperture 124 of the hollow shaft 72 and has ends thereof positioned in the wall apertures 96 of the side walls 92. The side walls 92 support the solid shaft 76, which in turn supports the hollow shaft 72 and the cam

follower 68. The solid shaft 76 has a diameter that is substantially complementary to the diameter of the wall apertures 96 and the inner diameter of the hollow shaft 72.

As illustrated in the drawings and described herein, the wall aperture diameter is smaller than the inner diameter of the cam follower 68 and the outer diameter of the hollow shaft 72. In some embodiments of the present invention, the wall aperture diameter is less than or equal to about ninety percent of the inner diameter of the cam follower 68. In other embodiments of the present invention, the wall aperture diameter is less than or equal to about seventy-five percent of the inner diameter of the cam follower 68. In further embodiments of the present invention, the wall aperture diameter is less than or equal to about fifty percent of the inner diameter of the cam follower 68. In still further embodiments of the present invention, the wall aperture diameter is less than or equal to about thirty percent of the inner diameter of the cam follower 68. The percentages discussed in the embodiments are not meant to be limiting and, therefore, other percentages relating to the wall aperture diameter and the inner diameter of the cam follower 68 are still within the spirit and scope of the present invention.

The wall aperture diameter is also smaller than the outer diameter of the cam follower 68. In some embodiments of the present invention, the wall aperture diameter is less than or equal to about thirty percent of the outer diameter of the cam follower 68. In other embodiments of the present invention, the wall aperture diameter is less than or equal to about twenty percent of the outer diameter of the cam follower 68. In further embodiments of the present invention, the wall aperture diameter is less than or equal to about fifteen percent of the outer diameter of the cam follower 68. In still further embodiments of the present invention, the wall aperture diameter is between about ten and about twenty-five percent of the outer diameter of the cam follower 68. The percentages discussed in the embodiments are not meant to be limiting and, therefore, other percentages relating to the wall aperture diameter and the outer diameter of the cam follower 68 are still within the spirit and scope of the present invention.

With particular reference to Fig. 4, one manner of assembling the finger follower 28 will be described. The rolling elements 112 are inserted into the outer ring aperture 116 and engage the interior surface of the outer ring 108 in a circular arrangement (as shown in Fig. 4) to define the cam follower aperture 120. The hollow shaft 72 is inserted into the cam follower aperture 120 and the outer surface of the hollow shaft 72 provides an inner bearing surface 126 (see Fig. 4) for the rolling elements 112. The assembled outer ring

108 and rolling elements 112 of the cam follower 68 and the hollow shaft 72 are positioned in the body aperture 88 and the shaft aperture 124 is aligned with the wall apertures 96. The solid shaft 76 is inserted into the aligned wall apertures 96 and the shaft aperture 124 and is supported by the side walls 92. The solid shaft 76 may be press fit, welded, staked or otherwise retained in the wall apertures 96. Although assembly of the finger follower 28 has been described in the manner above, the finger follower 28 can be assembled in other manners derivable from the components of the finger follower 28.

The finger follower 28 includes many embodiments of rotation. These embodiments relate to rotation of the cam follower 68, the hollow shaft 72, and the solid shaft 76 with respect to each other and with respect to the main body 64 of the finger follower 28. In a first embodiment, the hollow shaft 72 is positioned loosely in the cam follower aperture 120 to facilitate rotation of the cam follower 68 with respect to the hollow shaft 72, the solid shaft 76 is press fit in the shaft aperture 124 of the hollow shaft 72 or otherwise interconnected with the hollow shaft 72 to prevent rotation between the hollow shaft 72 and the solid shaft 76, and the solid shaft 76 is press fit in the wall apertures 96 or otherwise interconnected with the side walls 92 to prevent rotation between the solid shaft 76 and the main body 64. In this embodiment, only the cam follower 68 is rotatable with respect to the main body 64. To facilitate the first embodiment rotation, the hollow shaft 72 has a sufficiently sized outer diameter to ensure that the hollow shaft 72 engages the cam follower 68 at the inner diameter thereof, for example, in the illustrated embodiment, along the rolling elements 112, to an extent that facilitates rotation of the cam follower 68 with respect to the hollow shaft 72. Rotation in the first embodiment is also facilitated by the solid shaft 76 having a sufficiently sized diameter to ensure that the solid shaft 76 engages the hollow shaft 72 at the inner diameter thereof to prevent rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 having a sufficiently sized diameter to ensure that the solid shaft 76 engages sides of the wall apertures 96 to prevent rotation of the solid shaft 76 with respect to the main body 64.

In a second embodiment, the hollow shaft 72 is positioned loosely in the cam follower aperture 120 to facilitate rotation of the cam follower 68 with respect to the hollow shaft 72, the solid shaft 76 is positioned loosely in the shaft aperture 124 of the hollow shaft 72 to facilitate rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 is press fit into the wall apertures 96 or otherwise interconnected to the side walls 92 to prevent rotation of the solid shaft 76 with respect to the main body

64. In this embodiment, the cam follower 68 is rotatable with respect to the hollow shaft 72, the solid shaft 76, and the main body 64. Also in this embodiment, the hollow shaft 72 is rotatable with respect to the cam follower 68, the solid shaft 76, and the main body 64. Rotation of the hollow shaft 72 with respect to the main body 64 and solid shaft 76 allows the load bearing point on the hollow shaft 72 to continuously change. As such, the hollow shaft 72 experiences more even wear and longer life. To facilitate the second embodiment rotation, the hollow shaft 72 has a sufficiently sized outer diameter to ensure that the hollow shaft 72 engages the cam follower 68 at the inner diameter thereof to an extent that facilitates rotation of the cam follower 68 with respect to the hollow shaft 72. Rotation in the second embodiment is also facilitated by the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages the hollow shaft 72 at the inner diameter thereof to an extent that facilitates rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages sides of the wall apertures 96 to prevent rotation of the solid shaft 76 with respect to the main body 64.

In a third embodiment, the hollow shaft 72 is positioned loosely in the cam follower aperture 120 to facilitate rotation of the cam follower 68 with respect to the hollow shaft 72, the solid shaft 76 is positioned loosely in the shaft aperture 124 of the hollow shaft 72 to facilitate rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 is positioned loosely in the wall apertures 96 to facilitate rotation of the solid shaft 76 with respect to the main body 64. In this embodiment, the cam follower 68, the hollow shaft 72, and the solid shaft 76 are all rotatable with respect to each other and are all rotatable with respect to the main body 64. To facilitate the third embodiment rotation, the hollow shaft 72 has an outer diameter sufficiently sized to ensure that the hollow shaft 72 engages the cam follower 68 at the inner diameter thereof to an extent that facilitates rotation of the cam follower 68 with respect to the hollow shaft 72. Rotation in the third embodiment is also facilitated by the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages the hollow shaft 72 at the inner diameter thereof to an extent that facilitates rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages sides of the wall apertures 96 to an extent that facilitates rotation of the solid shaft 76 with respect to the main body 64.

In a fourth embodiment, the hollow shaft 72 is positioned loosely in the cam follower aperture 120 to facilitate rotation of the cam follower 68 with respect to the hollow shaft 72, the solid shaft 76 is press fit in the shaft aperture 124 of the hollow shaft 72 or otherwise interconnected with the hollow shaft 72 to prevent rotation between the hollow shaft 72 and the solid shaft 76, and the solid shaft 76 is positioned loosely in the wall apertures 96 to facilitate rotation of the solid shaft 76 with respect to the main body 64. In this embodiment, the cam follower 68 and the solid shaft 76 are rotatable with respect to the main body 64. To facilitate the fourth embodiment rotation, the hollow shaft 72 has an outer diameter sufficiently sized to ensure that the hollow shaft 72 engages the cam follower 68 at the inner diameter thereof to an extent that facilitates rotation of the cam follower 68 with respect to the hollow shaft 72. Rotation in the fourth embodiment is also facilitated by the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages the hollow shaft 72 at the inner diameter thereof to an extent that prevents rotation of the hollow shaft 72 with respect to the solid shaft 76, and the solid shaft 76 having a diameter sufficiently sized to ensure that the solid shaft 76 engages sides of the wall apertures 96 to an extent that facilitates rotation of the solid shaft 76 with respect to the main body 64.

Referring to Fig. 7, another embodiment of the finger follower is illustrated. Common elements are identified by the same reference numbers " ' ".

The finger follower 28' includes a solid shaft 76' having an enlarged head portion 128 at each end thereof. The enlarged head portions 128 are positioned in the wall apertures 96' and are engageable with a lip 132 defined in each of the wall apertures 96' to prevent substantial lateral movement of the solid shaft 76' with respect to the main body 64'. The solid shaft 76' in this embodiment can be, for example a rivet, a nut and bolt combination, a shaft and lock washer combination, or any other device having end portions large enough to engage the lips 132 of the wall apertures 96' to prevent substantial lateral movement of the shaft 76'. The finger follower 28' illustrated and described in this embodiment can have any of the rotation embodiments described above and can be assembled in a similar manner to that described above or in any other manner derivable from the components of the finger follower 28'.

The embodiments described above and illustrated in the figures are presented by way of example only and not intended as a limitation upon the concepts and principles of

the present invention. As such, it will be appreciated by one having ordinary skill in the art that various changes in the elements and their configurations and arrangements are possible without departing from the spirit and scope of the present invention as set forth in the appended claims.

5 * * *